OPENING THE LOW FREQUENCY WINDOW FOR ASTROPHYSICS

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SCIENTIFIC OBJECTIVES: The opening of a new spectral window for astronomical investigations has always resulted in major discoveries, significant insights into astrophysical processes, and an enrichment of our understanding of the universe. Frequencies below ~30 MHz are a range which is totally inaccessible or extremely difficult to observe from the ground due to ionospheric absorption and scattering. These frequencies represent a region of the spectrum that is essentially unexplored by astronomy but which, at $\sim 10^6$ Hz, is likely to display phenomena as different from those at centimeter radio wavelengths ($\sim 10^9$ Hz) as centimeter radio phenomena are from infrared ($\sim 10^{12}$ Hz), or infrared are from the ultraviolet ($\sim 10^{15}$ Hz), or ultraviolet are from the X-ray ($\sim 10^{18}$ Hz). Because of this large gap in our knowledge, the likelihood of discovering new processes and objects is great, even though many worthwhile projects can already be defined for a new instrument. The need to open this new window has been recognized by the Radio Astronomy Panel of the Bahcall Committee and detailed at international workshops (see Kassim & Weiler 1990). Plans for Low Frequency Space Arrays (LFSA) are under development.

THE ORIGIN OF COSMIC RAYS -- AN 83 YEAR OLD MYSTERY: Perhaps the most fundamental question still remaining from the era of classical physics is the origin of cosmic rays. Cosmic rays (CR) represent the most energetic form of matter and trace the highest energy phenomena. At frequencies below 30 MHz there is a real possibility for probing the particle acceleration process in SNRs and addressing the issue of the origin of CRs.

GALACTIC NONTHERMAL BACKGROUND: In studies of the distributed nonthermal background emission of the Milky Way different frequencies emphasize different physical processes: the surveys of ?-ray emission are sensitive to the interaction of cosmic rays with the ambient interstellar gas; optical surveys emphasize stars and ionized hydrogen (HII) regions; and IR surveys enhance visibility of the relatively cold interstellar dust. Radio frequency studies are most sensitive to the relativistic CR electrons and interstellar magnetic fields. However, there are problems in explaining the observed break in the cosmic ray electron energy spectrum near 3 GeV which is equivalent to the background radio spectrum break at ~300 MHz and low frequency observations may be able to provide clues to the relevant loss and injection mechanisms.

GALACTIC DIFFUSE FREE-FREE ABSORPTION: By observing a large number of extragalactic radio sources and determining their low frequency spectra as a function of Galactic latitude and longitude, it will be possible to measure the distribution of absorption by the diffuse, interstellar gas in the Milky Way. Combining survey results at the several frequencies available to a LFSA and the low resolution, higher frequency maps from the literature, we can successfully separate the thermal absorption and nonthermal emission components of the Galaxy.

INTERSTELLAR SCATTERING AND REFRACTION: It is generally accepted that small scale ($\sim 10^9$ cm) fluctuations in electron density in the interstellar medium can diffractively scatter radio waves from a background source. Less clear is the ability of somewhat larger irregularities ($\sim 10^{13}$ cm) to refractively focus and defocus radio waves. The questions which can be addresses at low frequencies are: What is the correct form of the irregularity power spectrum? Is the irregularity spectrum ever anisotropic? How common are refractive distortions and refractive scintillation? What is the origin of the turbulence and how is it distributed throughout the Galaxy?

EXTRAGALACTIC SOURCES: A LFSA can detect thousands of discrete sources and study the brighter ones for such properties as integrated spectrum, surface brightness and spectral index distribution, and source counts ("log(N)/Log(S)"). This is especially important since, due to synchrotron radiative lifetimes, the relativistic electrons which a LFSA detects are, in general, far older than those normally studies by radio astronomy.

SPECTRA: It has long been known that the radio spectral index (a) is a function of frequency a(v) and that the measurement of this frequency dependence is important fro understanding the physics of the emission and absorption process in the sources. At present, very little is known about source spectra at frequencies as low as 20 MHz and practically nothing has been measured for v < 10 MHz.

SUPERNOVA REMNANTS AND PULSARS: Low frequency radio observations provide a unique means for investigating SNRs, their interaction with the ISM, and the shock acceleration processes. A number of milli-second pulsars have spectra that are very steep with flux densities that continue to increase down to the lowest observed frequency of ~10 MHz. These pulsars, although non-pulsing due to interstellar scattering at these frequencies, are among the strongest sources in the sky at 10 MHz.

COHERENT EMISSION: A very exciting possibility at low frequencies is the detection of coherent radiation. There are valid physical reasons to anticipate that the smaller distance between individual radiating electrons measured in terms of the electromagnetic wavelength is likely to amplify collective radiative modes.